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EUROPEAN PATENT APPLICATION

21 Application number: 86304549.8

61 Int. Cl.⁴: F 02 B 37/12

22 Date of filing: 13.06.86

30 Priority: 19.06.85 GB 8515502

43 Date of publication of application:
07.01.87 Bulletin 87/2

64 Designated Contracting States:
DE FR GB SE

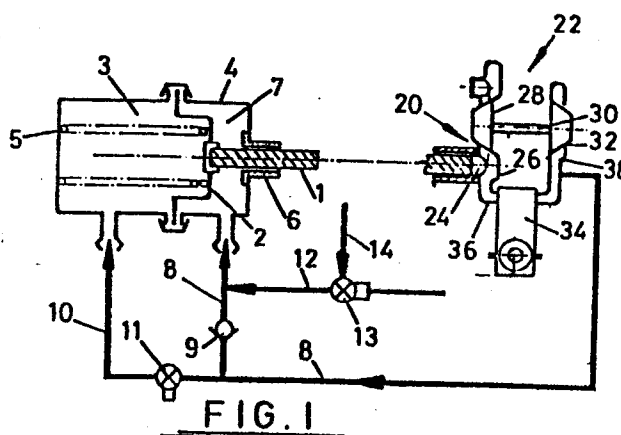
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54 A variable inlet area turbine turbocharger.

57 A variable inlet area turbine turbocharger for an internal combustion engine. A compressor is driven by a turbine having an inlet and an outlet, and the turbine inlet area is controlled as a function of a control pressure signal such that the turbine inlet area increases as a direct function of the control pressure signal. The control pressure signal corresponds to whichever is the greater of the turbine inlet pressure and the compressor outlet pressure.



- 1 -

A VARIABLE INLET AREA TURBINE TURBOCHARGER

This invention relates to a variable inlet area turbine turbocharger.

5 Various proposals have been made for varying the effective inlet area of the turbine of a turbocharger for an internal combustion engine. Typically these proposals provide that at low engine speed or low turbocharger compressor output pressure (boost
10 pressure) the effective turbine inlet area is decreased to increase the velocity of the exhaust gas entering the turbine wheel, and that at high engine speed or high boost pressure the effective turbine inlet area is increased to reduce the velocity of the
15 exhaust gas entering the turbine wheel.

Published European Patent Specification Nos. 0080810, 0095853 and 0131406 describe mechanisms which vary the effective inlet area of a turbocharger turbine by displacement of a movable member which
20 forms one side wall of the turbine nozzle array. Displacement of the movable member may be in response to an engine operating parameter such as engine speed or boost pressure or a combination of such parameters. One or more actuators connected to the
25 movable member move the member between maximum area and minimum area positions. A pre-loading spring may be conveniently arranged to bias the movable member towards the minimum area condition, the member being moved towards the maximum area condition by fluid
30 pressure acting against a diaphragm within the actuator to overcome the bias of the spring. The fluid pressure may be provided by air from the turbocharger compressor outlet or air from an external source such as an engine driven compressor.

35 For such systems to function satisfactorily it is necessary to control the displacement of the

movable member as a function of ~~one~~ or ~~more~~ engine operating parameters to ~~achieve an~~ effective turbine inlet area which ~~optimizes~~ engine performance throughout the engine operating speed and load range.

5 A partial form of control is achieved by what are referred to as boost control systems in which the effective turbine inlet area is varied in proportion to the turbocharger compressor outlet pressure. In the simplest form this may be achieved by admitting
10 the compressor outlet pressure directly to a spring pre-loaded diaphragm actuator. By suitable sizing of the diaphragm and spring the system is substantially self-regulating giving good engine transient response. However, such a system is not responsive
15 to either engine speed or engine load and does not give the turbine inlet area that produces the most efficient operation of the engine under all operating conditions.

 A more complex control system is described in
20 European Patent Application No. 84-306273.8 in which means are provided for varying the effective turbine inlet area as a function of engine rpm. At high rpms the effective inlet area is maintained substantially in its maximum area condition, at low rpms the
25 effective inlet area is maintained substantially in its minimum area condition, and at intermediate rpms the effective inlet area increases with increases in engine rpm. A signal representing the actual effective inlet area is fed back to the inlet area
30 controlling actuator and the position of the actuator is corrected by the feedback signal to achieve a predetermined effective inlet area.

 Although the above system provides optimum control under certain operating conditions it does
35 have some drawbacks. The transient response is not

as good as that obtained using simple compressor boost pressure systems, and the effective inlet area is varied irrespective of engine load. The system is also complicated and, as a result, suffers from a high manufacturing cost. At low boost pressures it is also possible for exhaust gas to flow through the actuator and overheat the actuator diaphragm.

It is known from published European Patent Specification No. 0108905 to provide a bypass conduit between the turbine inlet and compressor outlet of a turbocharger, the bypass incorporating a non-return valve which permits gas flow only from the compressor to the turbine inlet. The inlet area of the turbine is however not controlled by the pressure in the bypass conduit which is provided to improve low speed running rather than to control turbine inlet area.

U.S. Patent Specification No. 4499731 describes a turbocharger in which a conduit is provided between the turbine inlet and the compressor outlet, the conduit incorporating a non-return valve. This arrangement is provided to avoid surging of the compressor at low gas flow rates. The turbine inlet area is not a function of the pressure in the conduit.

It is an object of the present invention to provide an improved variable turbine inlet area turbocharger.

According to the present invention, there is provided a variable inlet area turbine turbocharger for an internal combustion engine, the turbocharger comprising a turbine having an inlet and an outlet, a compressor driven by the turbine and having an inlet and an outlet, and means for controlling the turbine inlet area as a function of a control pressure signal such that the turbine inlet area increases as a direct function of the control pressure signal,

wherein the control pressure signal corresponds to whichever is the greater of the turbine inlet pressure and the compressor outlet pressure.

5 The control pressure may be the pressure within a chamber, a first conduit connecting the pressure chamber to the turbine inlet, and a second conduit connecting the pressure chamber to the compressor outlet, the second conduit incorporating a non-return valve which closes when the pressure on the side of
10 the valve remote from the pressure chamber is less than the pressure on the other side of the valve.

 The pressure chamber may be defined on one side of a spring pre-loaded diaphragm. The diaphragm may be connected to an actuator which extends across and
15 through the pressure chamber wall to an inlet area control mechanism, the first conduit being formed at least in part by a passageway into the chamber through which the actuator extends.

 By connecting the actuator to both the
20 compressor outlet pressure and to the turbine inlet pressure the system becomes responsive to a wider range of engine rpm and load combinations than for systems operated by compressor outlet pressure alone. This is because at low engine load, high rpm
25 operating conditions the turbine inlet pressure can increase to higher values than the compressor outlet pressure. Connecting the turbine inlet pressure to the actuator enables this characteristic to be used to increase the turbine effective inlet area at high
30 engine rpm and low engine load operating conditions and thereby reduce pumping losses.

 Means may be provided for connecting a source of high-pressure air from an external source to the pressure chamber when the engine speed exceeds a
35 predetermined threshold. This maintains the turbine inlet area at its maximum. Below the predetermined

threshold the external source will be disconnected from the pressure chamber in normal circumstances, although if for example an exhaust brake is fitted to the engine it may be desirable to supply air from the external source to the actuator when the exhaust
5 brake is operated.

A third conduit may be provided connecting the compressor outlet to the side of the diaphragm remote from the pressure chamber. A pressure regulator is provided in the third conduit so that the pressure
10 delivered to the diaphragm through the third conduit corresponds to either the compressor outlet pressure or, where the compressor outlet pressure exceeds a predetermined threshold, to a preset level determined by the pressure regulator. In this arrangement, the
15 pressure supplied to the diaphragm via the regulator may be used rather than or as well as a spring to effectively pre-load the diaphragm. Where the third conduit is provided the operation of the device is the same as where no third conduit is provided except
20 when the compressor output pressure is less than the predetermined threshold set by the pressure regulator. When the compressor output pressure is less than the regulated pressure the turbine inlet area effectively decreases as the compressor output
25 pressure increases assuming a constant turbine inlet pressure. This provides an additional degree of freedom to the system designer when determining the relationship between turbine inlet area, compressor outlet pressure and turbine inlet pressure.

30 An embodiment of the present invention will now be described by way of example with reference to the accompanying drawings, in which :

Fig. 1 is a schematic illustration of an embodiment of the present invention;

35 Fig. 2 illustrates the variation in inlet area

with respect to compressor outlet pressure (boost pressure) and turbine inlet pressure in an arrangement in accordance with the prior art;

5 Fig. 3 illustrates the variation in inlet area with respect to boost pressure and turbine inlet pressure in accordance with an embodiment of the invention which is a modification of that shown in Fig. 1; and

10 Fig. 4 illustrates the variation in inlet area with respect to boost pressure and turbine inlet pressure in the embodiment of the invention illustrated in Fig. 1.

Referring to Fig. 1, an actuator rod 1 is connected to a flexible diaphragm 2 secured between component parts 3 and 4 of a diaphragm housing. The
15 end of the actuator rod 1 remote from the diaphragm 2 is secured to a mechanism 20 for controlling the turbine inlet area of a turbocharger 22 to which the device is fitted. The mechanism attached to the rod 1 may be of the type illustrated for example in
20 published European Specification No. 0080810 although it will be appreciated that any suitable turbine inlet area adjusting mechanism could be actuated by the rod 1 such as an annular ring 24 displaceable
25 into a turbine inlet housing 26 that surrounds a turbine wheel 28 of the turbocharger. The turbine wheel is journaled in the turbocharger by a shaft 30, which also connects to and journals a compressor wheel 32. Exhaust gases from an internal combustion
30 engine 34 pass through a manifold 36 and across the turbine 28 thereby rotating it so that the compressor wheel pressurizes air for delivery through a compressor outlet 38 to the internal combustion engine.

35 A pre-loading spring 5 is positioned between the diaphragm 2 and the housing component 3 so as to urge

the diaphragm and the rod 1 to the right in Fig. 1.

5 The rod 1 extends through a sleeve 6 which defines a restricted passageway around the rod 1 which communicates at one end with a chamber 7 defined between the diaphragm 2 and the housing component 4 and at the other end with the turbine inlet housing 26. Thus the passageway defined by the sleeve 6 around the rod 1 constitutes a first conduit through which gas may flow to and from the chamber 7.

10 The chamber 7 is connected by a second conduit 8 to the turbocharger compressor outlet 38. A non-return valve 9 is provided in the conduit 8 such that the non-return valve 9 closes when the pressure in the conduit 8 on the side of the valve 9 adjacent the chamber 7 exceeds the pressure in the conduit 8 on the other side of the valve 9. When the valve 9 is open the pressure within chamber 7 is substantially the same as the compressor outlet pressure. When the valve 9 is closed the pressure in chamber 7 corresponds to the turbine inlet pressure. The position of the rod 1 and hence the inlet area of the turbine is a function of the differential pressure across the diaphragm 2 and the spring constant and preload of the pre-loading spring 5.

20 Referring now to Fig. 2, this shows a simple graphical representation of the variation in turbine inlet area with respect to boost pressure (that is compressor outlet pressure) and turbine inlet pressure which would apply if in accordance with prior art arrangements the chamber 7 was isolated from the turbine inlet pressure and the non-return valve 9 was omitted. Boost pressure A corresponds to the boost pressure at peak torque when the actuating mechanism has reduced the inlet area to 50% of its maximum. Boost pressure B corresponds to an intermediate pressure which is for example 0.2 bar

above boost pressure A and corresponds to movement of the actuator mechanism so as to provide maximum turbine inlet area. Variations in pressure above pressure B or below pressure A do not affect the turbine inlet area. Between pressures A and B there is a linear change in the turbine inlet area with changes in the boost pressure. The typical engine operating envelope is indicated by dashed line C. Thus it can be seen that with a simple control of turbine inlet area in dependence upon the boost pressure only the system is relatively inflexible to changes in engine load and/or turbine inlet pressure.

Looking now at Fig. 3 this is an equivalent illustration to that of Fig. 2 but illustrating the effect on the turbine inlet area of connecting the chamber 7 of Fig. 1 to the turbine inlet pressure via the member 6 and the provision of the non-return valve 9. It can be seen that in low load conditions the control of turbine inlet area is a function of the turbine inlet pressure rather than the boost pressure. The line D indicates a typical engine rpm line.

Referring again to Fig. 1, a third conduit 10 may be connected between the conduit 8 which carries the compressor output pressure and the side of the diaphragm 2 remote from the chamber 7. A pressure regulator 11 is connected in conduit 10 so that the pressure in conduit 10 corresponds to the compressor output pressure until that output pressure exceeds a predetermined threshold whereafter the pressure within conduit 10 is held at a predetermined level by the regulator 11. The pressure in conduit 10 thus effectively provides pre-loading to the diaphragm 2 which corresponds precisely with the function of the pre-loading spring 5 so long as the pressure 10 is at the predetermined level determined by the regulator

11 but the characteristic response of the device is changed when the pressure in conduit 10 corresponds to the pressure in conduit 8. The spring 5 may be dispensed with or reduced in strength to compensate for the fact that some pre-loading is now provided by the pressure delivered via conduit 10.

Referring now to Fig. 4, this is an illustration equivalent to those of Figs. 2 and 3 but illustrating the effect on turbine inlet area when the conduit 8 and valve 9 and the conduit 10 and regulator 11 are both provided. It will be seen that at low boost pressures when the regulator 11 is operating beneath its predetermined threshold the turbine inlet area increases more rapidly with turbine inlet pressure in the case of Fig. 4 than in the case of Fig. 3.

Referring again to Fig. 1, a further feature of the illustrated arrangement is a conduit 12 which connects the conduit 8 on the side of the non-return valve 9 adjacent the chamber 7 to a solenoid controlled valve 13 which when operated connects the conduit 12 to a conduit 14 that in turn is connected to an external supply of pressurised air, for example an engine driven compressor. A control device can be provided (not shown) which monitors engine rpm and opens the valve 13 when a predetermined rpm is exceeded. This then supplies high pressure air via conduits 14, 12 and 8 to the chamber 7 causing the turbine inlet area to be increased to its maximum extent. Thus it is possible to override the relationship between turbine inlet area, boost pressure and turbine inlet pressure when a predetermined engine speed is exceeded.

As shown in Fig. 1 the turbine inlet pressure may be conveniently admitted to the chamber 7 through the clearance between the actuator rod 1 and the bearing member 6 which is supported in the diaphragm

- 10 -

housing component 4. It should be noted that although this communicates the chamber 7 and thus the diaphragm 2 with hot gases at the turbine inlet the presence of the non-return valve 9 prevents this hot gas from flowing continuously through the chamber 7 even if the turbine inlet pressure is greater than the compressor outlet pressure. Thus, the arrangement ensures that only a very small amount of hot gas is delivered to the chamber 7 and therefore the diaphragm 2 is protected against damage due to overheating. On the other hand when the compressor outlet pressure is greater than the turbine inlet pressure a flow of cooling air is driven through the chamber 7 and thence out through the member 6 to the turbine inlet. Thus the diaphragm is protected against damage due to overheating.

CLAIMS:

- 5 1. A variable inlet area turbine turbocharger for an internal combustion engine, the turbocharger comprising a turbine having an inlet and an outlet, a compressor driven by the turbine and having an inlet and an outlet, and means for controlling the turbine inlet area as a function of a control pressure signal such that the turbine inlet area increases as a
10 direct function of the control pressure signal, wherein the control pressure signal corresponds to whichever is the greater of the turbine inlet pressure and the compressor outlet pressure.
- 15 2. A turbocharger according to claim 1, wherein the control pressure is the pressure within a chamber, a first conduit connecting the pressure chamber to the turbine inlet, and a second conduit connecting the pressure chamber to the compressor
20 outlet, the second conduit incorporating a non-return valve which closes when the pressure on the side of the valve remote from the pressure chamber is less than the pressure on the other side of the valve.
- 25 3. A turbocharger according to claim 2, wherein the pressure chamber is defined on one side of a pre-loaded diaphragm.
- 30 4. A turbocharger according to claim 3, wherein the diaphragm is connected to an actuator which extends across and through the pressure chamber wall to an inlet area control mechanism, the first conduit being formed at least in part by a passageway into the chamber through which the actuator extends.
- 35 5. A turbocharger according to claim 4, comprising means for connecting a source of high pressure air from an external source to the pressure chamber when the engine speed exceeds a predetermined

- 12 -

threshold.

5 6. A turbocharger according to claim 3, 4 or 5,
comprising a third conduit which connects the
compressor outlet to the side of the diaphragm remote
from the pressure chamber, and a pressure regulator
connected in the third conduit so that the pressure
delivered to the diaphragm through the third conduit
corresponds to the compressor outlet pressure when
the compressor outlet pressure is less than a
10 predetermined threshold and to a preset level when
the compressor outlet pressure exceeds said
predetermined threshold, the preset level being
determined by the pressure regulator.

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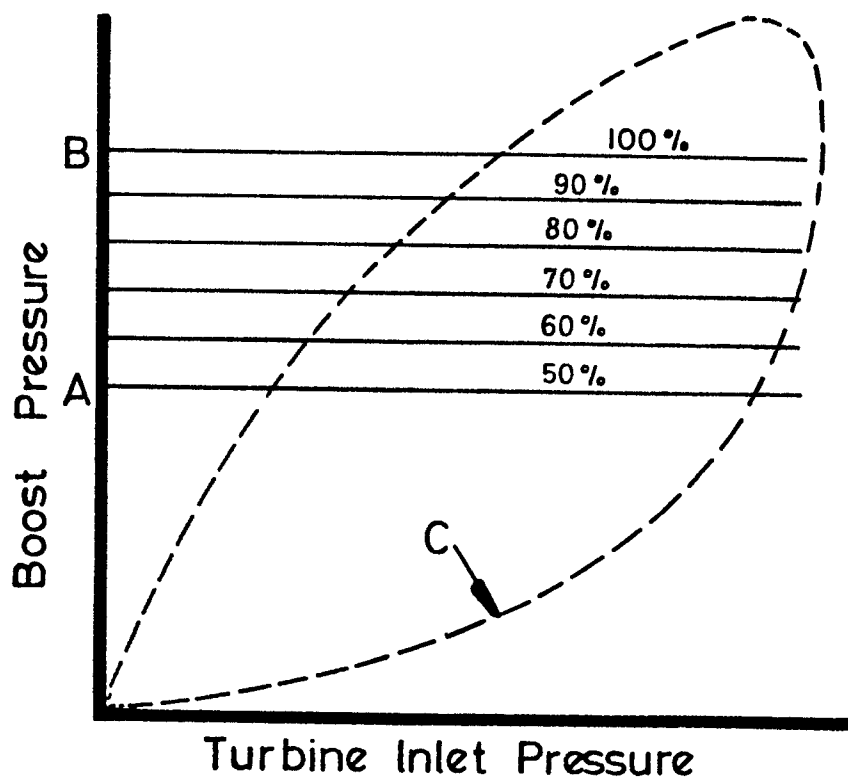
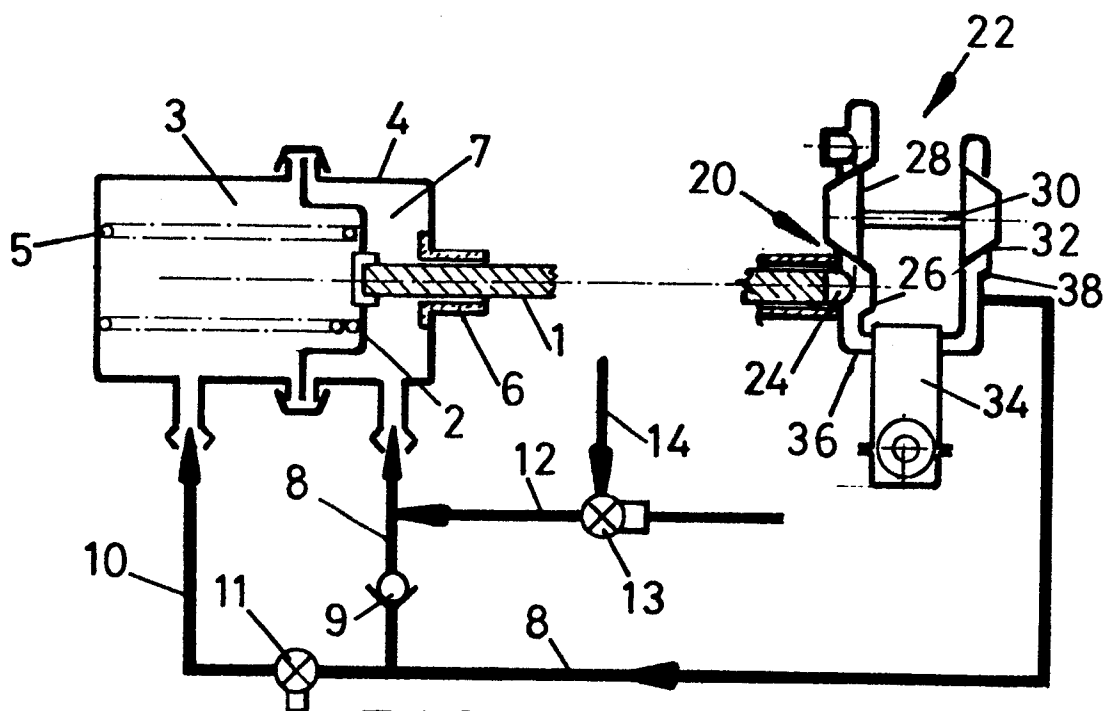


FIG. 2

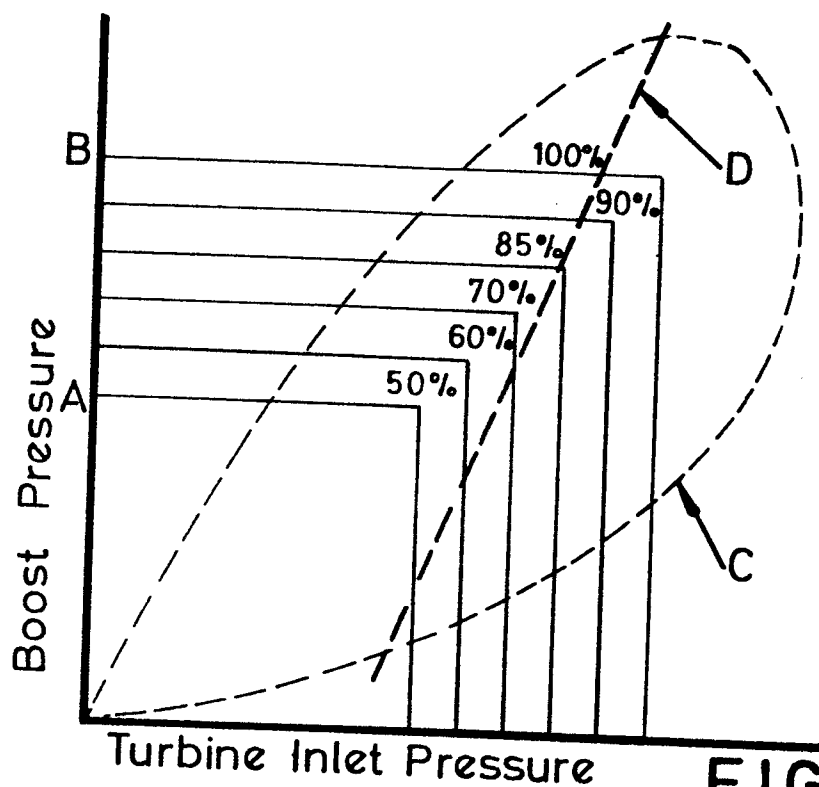


FIG. 3

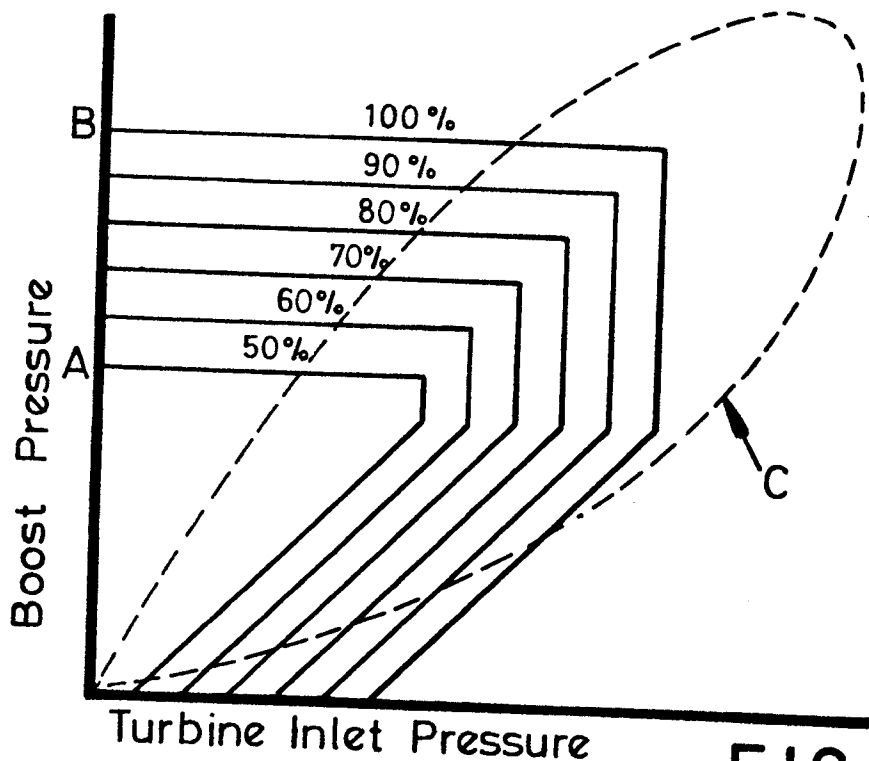


FIG. 4



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
X	US-A-4 292 807 (RANNENBERG) * Column 9, line 42 - column 11, line 62; figure 2 *	1	F 02 B 37/12
Y	---	2-6	
Y	US-A-4 336 688 (DELLIS) * Column 2, line 46 - column 4, line 57; figures 1-3 *	2,3	
Y	GB-A-2 039 610 (HITACHI) * Page 2, lines 7-17; figure 1 *	4	
Y	PATENTS ABSTRACTS OF JAPAN, vol. 8, no. 40 (M-278)[1477], 21st February 1984; & JP-A-58 195 023 (NIPPON JIDOSHA BUHIN SOGO KENKYUSHO K.K.) 14-11-1983	5	
Y	US-A-4 283 912 (CHOLVIN) * Column 2, line 55 - column 4, line 53; figures 1,2 *	6	
A	US-A-3 233 403 (MacINNES) * Column 3, line 10 - column 5, line 38; figures 1-5 *	1,3	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 25-09-1986	Examiner HAKHVERDI M.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons A : member of the same patent family, corresponding document	